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ORCHARD ENEMIES

IN THE

PACIFIC NORTHWEST.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., April 3, 1902.

SIR: I herewith transmit a manuscript by Prof. C. V. Piper, of the Washington Agricultural Experiment Station, Pullman, Wash., submitted at your request. I have examined the manuscript, and recommend its publication as a Farmers' Bulletin. The portion relating to fungous diseases and the remedies therefor has been approved by the Plant Physiologist and Pathologist.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATION.

ORCHARD ENEMIES IN THE PACIFIC NORTHWEST.

INTRODUCTION.

Within the past ten years the fruit-growing industry in the States of Washington, Oregon, and Idaho has developed very rapidly. With the possible exception of prunes, the greater part of the product is shipped as fresh fruit to Eastern markets, where it has already won a high reputation for quality.

Along with this rapid development of the industry there has been a much more rapid increase in the damage caused by insects and diseases. Ten years ago there was little or no need to fight orchard pests, as the injury caused by them was scarcely appreciable. At the present time, at least in the older sections, the fruit grower is compelled to combat insects or fungi or both, in order to grow marketable crops.

This marked change coming in so short a time, and in many cases involving serious loss, has naturally had a discouraging effect. In a few instances this discouragement has even led to the digging up of orchards. The increase in the amount of damage by orchard enemies has been the more depressing because the idea had gained considerable credence that the previous immunity from such loss was due to some special peculiarity of the soil or climate or both. Unfortunately this idea still prevails in sections where, for some reason or other, pests have not yet become a serious factor. At one time, when western Oregon apples were justly famous, the growers said: "We will never have wormy apples here because the climate is so moist." In the warm interior valleys orchardists now claim that fungous diseases will never be a menace because the climate is too hot and dry; and upon the interior uplands their competitors say that no insect or fungous enemy need ever be feared because of the winds and the cool nights. In all this there is a somewhat labored effort to consider as proven what is at best a hope. The experience of nearly every new region has been much the same. No place has yet been discovered where orchards will thrive where pests will not also thrive. The general truth of the statement is not affected by the well-known fact that the amount of damage caused by a particular insect or fungus varies greatly in different regions and in the same region from year to year.

The rapid spread of certain pests like the codling-moth and apple scab in recent years has led some to the opposite extreme view, namely, that pests are far more injurious here than in other fruit-growing regions. A careful comparison of the loss occasioned here in neglected orchards with similar injury in older States reveals no evidence to justify such a conclusion.

Many orchardists have been slow to adapt themselves to the new conditions caused by the introduction and spread of insects and fungous diseases. Although these new conditions have undoubtedly increased the cost of producing fruit, the growers who have used proper efforts to control insects and disease have been uniformly successful in raising profitable crops of high-grade fruits; on the contrary, the product of neglected orchards is, as a rule, so badly injured that most of it is unmarketable, or must be sold at a very low price.

Serving as object lessons, such results are doing much to increase rational efforts to combat orchard enemies, and undoubtedly the situation will become better from year to year, as the great majority of persons now setting out orchards realize beforehand that it is one of the factors necessary to success.

HORTICULTURAL DIVISIONS.

From a horticultural point of view there are three very distinct regions in the Pacific Northwest. These may be denominated as follows:

(1) **The Coast Region**, lying west of the Cascade Mountains.

(2) **The Inland Valleys**, having an altitude of 300 to 1,000 feet, for the most part irrigated, and in which the commercial growing of the peach is carried on.

(3) **The Inland Uplands**, ranging in altitude from 1,000 to 3,000 feet or more, where commercial peach culture is not practicable.

CONDITIONS AFFECTING ORCHARDS IN THE COAST REGION.

The most striking peculiarities in the region lying west of the Cascades are the very equable mean temperature throughout the year and the rather copious rainfall; periods of drought seldom occur, and then only during a short time in July or August. These conditions, which have favored the heavy forestation of the region, are quite different from those in any other portion of the United States, and have already given rise to a number of new agricultural problems. Only those which particularly concern orchards are discussed here. The humidity of the climate quickly results in trees becoming coated with a growth of lichens, and, later, true mosses, the whole being commonly denominated "moss," which nullifies to a considerable extent the effects of some spraying mixtures; hence, any practice to be completely successful must destroy this moss. Of the spraying compounds,

Bordeaux mixture and the sulphur-salt-lime wash are both efficient for this purpose.

The only practice that has been at all general in orchards here is winter spraying with the sulphur-salt-lime wash. Beyond any question this spray is effective on the Pacific coast against the San Jose scale. It also destroys the eggs of the green aphis and the red spider, and kills moss. It is not effective against the oyster-shell scale, nor, on mossy roughed-barked trees at least, against the woolly aphis of the apple; for apple-scab and blackspot apple canker it is of little or no value. There is no evidence at hand to indicate whether the sulphur-salt-lime wash is at all effective against the brown rot of stone fruits, but it is probably no more efficient for this than for the scab diseases. In view of these facts, winter treatment of trees west of the Cascades with sulphur-salt-lime is unsatisfactory.

The efficiency of this wash seems to depend on the caustic properties of the compounds of lime and sulphur. Its high value here against the scale insects has given rise to the idea that it is a specific against practically all the ills that affect orchard trees, an idea rudely dispelled by the record of actual experiences. As a matter of fact the value of the wash against most fungous diseases seems to be very small and not to be compared with that of Bordeaux mixture.

Up to the present time commercial fruit growing in the coast region has not been a prominent feature of its agriculture. Prune growing is as yet the one phase of fruit production that is conducted on a large scale, and this industry is confined mainly to Clark County, in Washington, and the Willamette Valley, in Oregon. Inasmuch as all stone fruits except the peach do remarkably well, and apples and pears of fine quality can be grown—in fact, fully equal to those of the inland regions—it seems strange that their production on a commercial scale has not been more fully developed. The principal explanation of the failure to do this seems to be the large loss occasioned by scab to the apple and pear, and by brown rot to the stone fruits. To a less degree the black-spot apple canker may have had a like effect. The control of these diseases, however, would seem to offer no more serious problems than do the codling moth and San Jose scale in the inland valleys. Be that as it may, it is certainly desirable that a large additional amount of experimenting be carried on to determine how far these factors are inimical to success. Another factor that may have something to do in limiting commercial fruit growing is the higher initial cost of the land.

A rational treatment for orchard trees in this region may perhaps be made most clear by considering each kind separately.

THE APPLE.

Throughout the coast region, apple-scab and blackspot apple canker cause the most serious losses. It is a conservative estimate that 75

per cent of the apples raised in the region are more or less affected by scab, and but a small portion of the trees are free from the canker.

On the contrary, the loss by insect damage is relatively small. In western Washington not over 10 per cent of the apples are affected by the codling-moth. In the Willamette Valley of western Oregon the same insect causes a loss of from 30 to 60 per cent of the apples, according to Professor Cordley.

An unimportant amount of damage is caused by the wooly aphis and by the oyster-shell scale, or bark louse. The San Jose scale is very rare in western Washington and by no means a serious factor in western Oregon.

An insect recently introduced from Japan, the apple fruit miner (*Laverna herellera*), may become a serious pest. As yet it is not widespread, and so little is known of its life history that no method of treatment can be recommended. It may easily be known by the sinuous passages bored through the fruit by the larvæ.

The control of fungous diseases in the coast region is rendered difficult owing to the frequent rains, especially those of spring and early summer. In the case of apple scab the two or three sprayings of Bordeaux mixture usually recommended are not sufficient. Five sprayings is probably the smallest number necessary to insure good results. In the light of present experience these are best applied as follows: The first, just before the flower buds open in spring; the second, just after the blosoms fall; the third, 10 to 12 days later; the fourth and fifth, at intervals of two weeks. The last two sprayings should be with ammoniacal copper carbonate, as the Bordeaux mixture causes fruit to russet, especially when damp weather follows the spraying. There is still need that much experimental work be done on this disease under the peculiar conditions existing, as it is much the worst enemy the apple grower has to contend with. The above suggestions are admittedly based on too meager a series of experiments.

The disease here designated blackspot apple canker, also known as "blackspot," "deadspot," "apple anthracnose," and "apple canker," is a serious enemy, especially of young apple trees. A detailed account of the disease and of the methods for controlling it is given farther on.

Where the average loss by the codling-moth is 10 per cent or less, it is a comparatively unimportant factor. It seems desirable, however, to add Paris green to the third spraying of Bordeaux mixture, 1 pound of the poison to each 150 gallons of liquid. Where, as in the Willamette Valley, the loss is greater, one or perhaps more additional sprayings with Paris green are necessary.

For the woolly aphis, summer sprayings of kerosene emulsion, 1 part to 12 parts water, have given very satisfactory results. In western Washington, at least, the root form seems not to occur.

THE PEAR.

Pear scab is the most serious disease yet affecting this fruit in the Coast region. It requires the same treatment as apple scab.

Blight, or "fire" blight, of the pear is yet unknown in western Washington, but it is reported from western Oregon. In view of the enormous damage this disease has caused in the inland regions, it is very desirable to prevent its spread as much as possible.

The pear-leaf blister-mite is of frequent occurrence.

THE CHERRY.

Brown rot, or fruit mold, is the only disease of serious consequence. The control of this disease is difficult, but two sprayings of Bordeaux mixture seem decidedly helpful. One of these should be just before the flowers open, the other immediately after the petals fall. It is decidedly helpful to prune the trees so that the tops are open and the fruit exposed as much as may be to the sunshine.

Of insects, the black aphis is periodically abundant. It can easily be destroyed with kerosene emulsion.

Gummosis, a disease of very obscure origin, is a frequent trouble with sweet cherries. Nothing satisfactory can be recommended in the way of treatment. The common practice of slitting the bark is, at best, of doubtful value. Trees grafted on wild stock are somewhat less subject to the disease.

THE PLUM AND THE PRUNE.

Like the cherry, both of these fruits are subject to the brown rot. While the disease varies greatly in severity from year to year, the gathering and burning of the mummified fruits should never be neglected. The thinning of the fruit so as to prevent clusters is also desirable. Spraying for this disease has given contradictory results, and much experimenting is yet necessary to determine whether it is profitable or not.

The peach-tree borer is prevalent in some sections, attacking particularly prune trees grafted on peach roots. Digging out the larvae in fall and spring with a knife is the usual method of control. In addition some growers mound up earth about the bases of the trees in May, a practice which would seem to be always desirable, and perhaps as good as any that can at present be recommended.

In the last few years the root disease caused by the mushroom, *Armillaria mellea*, has been prevalent in Clark County, Washington. Apparently it has been introduced, as it has not been found in adjacent woodlands. Besides the mushrooms which appear about the bases of the affected trees in the fall, the disease may be known by the black, string-like strands (rhizomorphs) which occur on the crown and roots.

These rhizomorphs are part of the vegetative body of the mushroom. The disease spreads by the spores produced on the mushrooms and by the rhizomorphs which grow along the roots of the affected trees and thus reach adjoining trees. No remedy is known for the disease, which is nearly always fatal, at least to prunes. The only real method of control is to dig up the affected trees, roots and all, and burn them. No new trees should be planted in the same spots for several years. An affected tree, if not at once dug up, should be isolated from adjoining trees by a ditch a foot wide and two feet deep. In any case the mushrooms should be gathered and destroyed when they appear. This particular kind is edible. Some growers have tested the efficacy of lime, placing it in considerable quantity about the roots of an affected tree, and it is claimed that in some cases the trees recovered. There is room for considerable investigation in testing the usefulness of lime, of Bordeaux mixture, and of other substances in this manner, though the chances are that none of them will prove satisfactory remedies.

In addition to the above, the prune especially is subject to two obscure ailments which are not caused by either insects or fungi. One of these is called "leaf curl," and is characterized by the leaf margins rolling in loosely toward the midrib, and usually becoming more or less yellowish. In bad cases many of these leaves fall off, and sometimes, at least, many of the prunes as well. The trouble usually occurs in July and August and seems due primarily to drought. At least it is common to see it in some orchards while absent from adjoining ones; and, in the same orchard, it may frequently be noticed that the trees in moister situations are normal in their appearance while the rest are affected by the "curl." This view is held by many orchardists, and the fact that the prune is thus affected in every part of the Northwest where it is cultivated lends considerable weight to the conclusion.

It is a noticeable fact, however, that some individual trees are more subject to the trouble than others. Where this is the case it is usually easy to find some secondary cause, such as injury to the crown by borers or by the mushroom disease, partial girdling due to the bark bursting, or an imperfect union of the scion and stock.

The other trouble is locally known as bark bursting, and seems confined to the Coast region. It was particularly prevalent in 1899. It is characterized by the splitting of the bark in an irregularly longitudinal direction, and not rarely being torn away from the wood for some distance on each side of the split. So far as observed, this occurs only in late winter or just before the buds burst in spring.

A current idea in regard to the trouble is that it results from the tree being bark bound, and a common practice based on this idea is to slit the bark from the branches to the ground. It is also claimed that leaf curl is a result of the tree's being bark bound and that the slitting

process releases the pressure of the bark so that the sap can flow more freely. The bark binding is supposed to result from the wood and inner bark growing more rapidly than the tough outer bark, the strain finally becoming so great that the bark bursts and even breaks away from the wood. To all of the above views there are vital objections. The supposition that bark binding interferes with the sap flow and thus causes leaf curl may be dismissed as absurd, for it is impossible for the bark to exert pressure enough to prevent the upward movement of water in the sapwood. It is also a fact that the bursting does not take place when the wood growth is greatest and the stretching of the bark most intense. On the contrary, it takes place, if at all, near the close of the winter season, when there is absolutely no growth.

That the bursting could be caused by low temperature alone seems out of the question, as in the coast region the winter temperature is so high that skating is a rare sport, and only twice in twenty years has the thermometer registered zero. In the inland areas much lower temperatures occur, but bark bursting is there unknown.

With our present knowledge of the trouble no adequate explanation can be given. It has been suggested that root pressure may have something to do with the phenomenon. The conditions in winter in the coast region are frequently such that the roots may be active in the relatively warm soil long before any leaves have developed in the branches. This would result in a considerable sap pressure within the tree, but it seems hardly probable that it could be great enough to burst the bark, even in case of a sudden drop in the temperature. Whatever the cause, the best remedy is to bind the bark at once, using a liberal supply of grafting wax of some sort to keep out fungus spores. The binding should be done with strips of cloth or burlap, which should be tightly drawn. If this is done promptly the wound will heal over nicely.

Slitting the bark is of doubtful value. However, it can do little harm, even if it does no good.

CONDITIONS AFFECTING ORCHARDS IN THE INLAND VALLEYS.

The Cascade Mountains separate two regions widely different in soil and climate. On the one side these have fostered the development of great forests; on the other almost antithetical conditions have resulted in the plains and hills being practically treeless. While the coast region has an abundant rainfall and no great extremes in temperature, the inland region, in many parts at least, has an insufficient rainfall and the extremes of heat and cold are more marked.

In the fruit-growing districts of the inland region there are well-marked differences between the valleys, where for the most part irrigation is practiced, and the uplands, where rainfall must be depended on.

The valleys here considered are those which lie at an altitude of 300 to 1,000 feet above the sea level, including practically all of the regions in which the peach thrives, and which in the main are cultivated under irrigation. In these valleys commercial fruit growing is, perhaps, more extensively engaged in at present than anywhere else in the Pacific Northwest.

The extremely favorable conditions, so far as pests are concerned, in these inland valleys lies in the absence of any serious fungous disease. Apple and pear scab do not occur; brown rot is reported from but one locality; blackspot canker is unknown. How far these conditions are due to climate, and how far to comparative isolation, is difficult to determine. The experience of most of the older fruit-growing communities is a warning to the fruit grower that there is little ground for hope of immunity from any particular pest on account of climatic influences. The absence of such serious enemies as peach yellows, brown rot, and plum curculio, not to mention others, is an important factor in successful orcharding in these valleys.

INSECT ENEMIES.

The following are the insect pests of most importance:

San Jose scale.—The first appearance of this insect in the Northwest seems to have been in the Snake River Valley, at Almota. At the present time the insect is abundant in most of the valleys and occasional on uplands. The universal practice is to spray in winter with the sulphur-salt-lime wash, which is completely effective when properly applied. Excepting that such winter applications entail a perennial expense, the advent of the insect has caused little damage. An incidental feature gained in peach orchards by these winter sprayings is the control of the peach-leaf curl, which occasionally caused considerable damage.

Codling moth.—Taken all in all this is the worst insect pest in the Northwest, and it is more destructive in these inland valleys than elsewhere. Owing to the long warm season, the insect may be found at almost any time, and in all stages, from May to September. It is commonly believed that in these valleys the insect has three or more annual broods, but this is by no means demonstrated. The experience of fruit growers has led them to spray from five to seven times each season to control this insect. The majority of orchardists use Paris green, but others secure as good results apparently with the cheaper arsenite of soda mixture. The sprayings as carried out by most growers are as follows: The first, just as soon as the petals fall; the second, two weeks later; the third, about July 10, and the remaining sprayings at intervals of two to three weeks, the last one being in September. A few growers supplement their spraying with the "banding system," and believe that the results secured justify the practice.

Aphides or plant-lice.—In some sections these are occasionally very abundant, especially those of the apple and plum. Kerosene emulsion is generally used to keep them down.

Peach moth or peach twig-borer.—This insect was abundant in 1897 and again in 1900 and 1901. Winter sprayings with kerosene emulsion as determined by experiments on Snake River are very effective. The sulphur-salt-lime wash seems to have no effect on the insect.

BACTERIAL AND FUNGOUS DISEASES.

Peach mildew (*Sphaerotheca pannosa*).—This disease is of general occurrence in peach orchards, but does comparatively little damage. Some years the disease is excessively abundant and other years scarce. I have never been able to detect any other reproductive organs than the conidia or summer spores. The fungus lives over winter on young twigs.

Up to the present time the disease has received no specific treatment, and, in view of the relatively small damage done, it is probably not profitable to spray against it.

Pear blight.—This disease has been extremely destructive in almost every part of the inland region for three years past. It is estimated that 70 per cent of the pear trees in the region are either killed or so badly injured as to be of little value. Some varieties have withstood the disease much better than others, but strangely enough the same variety seems to differ in its degree of resistance in different localities.

CONDITIONS AFFECTING ORCHARDS IN THE INLAND UPLANDS.

By the uplands are meant the valleys and rolling hills having an elevation of from 1,000 to 3,000 feet. In general, such lands comprise the wheat-growing area of the inland region. Dependence is placed entirely upon the rainfall, which in some localities is barely sufficient to insure a crop. In wheat raising, indeed, the most common practice is to summer fallow the land each alternate year, and in the drier localities this is necessitated by the scanty rainfall. During recent years a great acreage of fruit trees has been planted in such lands, and the hardier fruits have proven very satisfactory investments.

INSECT ENEMIES.

Thus far there has been but very slight damage from insect pests. How much this is due to the relative newness and isolation of the orchards, and how much to the climatic conditions, it is difficult to determine. The following notes on such insects and diseases as have already appeared give the only indications we have as regards their probable future behavior:

Codling moth.—In the past four or five years the average damage caused by this insect has been less than 10 per cent. It is generally thought that this low percentage of damage is due to the cool nights of the region, to some extent aided by the prevailing fresh winds. Inasmuch as the damage occasioned by this insect in Snake River Valley is always large, while on the uplands 2,000 feet higher and only 1 to 3 miles distant the loss is nearly always small, considerable weight is given to this opinion. Nevertheless in occasional orchards in the uplands the loss has in certain years, notably 1898, reached as high as 25 and even 40 per cent. This is commonly ascribed to the peculiarities of the particular season, which may be the true explanation; but in view of the newness of the orchards it can not be considered as demonstrated.

San Jose scale.—Up to four years ago this insect was not known to occur in the interior uplands, and it was generally believed that it could not thrive there. Its occurrence in at least 4 orchards located at an altitude of about 2,000 feet has dispelled this notion. In each case, however, the spread of the insect in the orchard has been very slow, so that but little damage has been caused though no attempt has been made to destroy it. These facts would seem to point strongly to the conclusion that outside of the peach-growing districts the San Jose scale is not likely to prove a serious menace. In every case, however, no pains should be spared to exterminate the insect, and this, by hard pruning and thorough spraying, can be accomplished. It is far more economical to exterminate the insect, if possible, than to be compelled to spray for it every year or two.

BACTERIAL AND FUNGOUS DISEASES.

Pear blight.—This terrible disease has been very destructive in the past three years, from 60 to 80 per cent of the pear trees in the region having been practically destroyed. Quince trees, too, have suffered severely, but apple trees have scarcely been affected. In view of the highly destructive character of this disease, the future of pear culture in the Northwest is very uncertain.

Apple scab.—Of the lands here called the inland uplands, the greater portion is treeless prairie. To the northward and eastward, however, the prairies merge into the forest-clad foothills of mountain ranges, where the rainfall is somewhat greater. In these forested regions, especially in northern Idaho, the apple scab has been more or less prevalent for several years past, the amount of the damage varying in different seasons. On the adjoining prairie regions the disease seems to be spreading slowly, but until now not 2 per cent of the apples have been affected. Outside of the forest belt, at least, the present experience would indicate that the disease is not apt to become an important factor.

LEGISLATION.

While differing considerably in character, the horticultural laws of Oregon, Washington, and Idaho aim to prevent the introduction and to control the spread of injurious insects or diseases by all practicable means, namely: Nursery stock inspection, quarantine of suspected fruit, and compulsory treatment of infested orchards.

NURSERY-STOCK INSPECTION.

Perhaps more attention has been given to this phase of the horticultural laws than to any other. Unquestionably the effect has been to make nurserymen much more careful regarding the quality of the nursery stock they ship. Without doubt, too, this inspection has to some degree limited the spread of well-known insects and diseases. It is very probable, indeed, that the cost of the service is more than repaid by the benefits derived. But as a means of preventing the introduction of new pests, nursery-stock inspection has not succeeded.

With the exception of a very few dangerous insects and diseases, among them peach yellows and plum curculio, practically every serious orchard pest is now known to occur in the Northwest. It may be, and probably is, the fault of an imperfect service rather than of the method, but the fact remains that the wished-for result was not attained, and, of course, is not now attainable.

QUARANTINE OF INFESTED FRUIT.

In the enforcement of this phase of the horticultural laws, the exercise of a certain discretion is noticeable. In few, if any, cases have domestic fruits infested or injured by apple scab, codling moth, or peach moth been quarantined. On the contrary, when infested with San Jose scale, they have usually been quarantined and condemned. Imported fruit, as a rule, is subjected to much stricter quarantine than is domestic fruit. In numerous cases infested oranges and lemons have been quarantined and the owners compelled to fumigate or destroy them. The apparent object of this is not to protect orchards, as they are in nowise threatened by such insects, but to discourage shippers and importers from handling such infested fruit. In so far as imported fruits are of the same sorts as domestic, it is certainly desirable that the quarantine laws be strictly enforced, especially as regards Japanese fruits. The introduction of the apple fruit-miner through that source is an object lesson that should be heeded. As was pointed out in the Yearbook of the Department of Agriculture for 1897 by Dr. L. O. Howard, there are a number of Japanese insects which, if introduced, are likely to become serious pests.

COMPULSORY TREATMENT OF INFESTED ORCHARDS.

The general enforcement of horticultural laws of this class is attended with difficulty. The actual inspection of every orchard in the State demands an amount of work that the service provided does not succeed in accomplishing. While undoubtedly the most direct means of controlling pests, its efficiency would probably be increased by limiting the number of insects or diseases whose control is attempted. The sentiment seems to be growing among orchardists in the Northwest that every means, including compulsory treatment, should be enforced to control insects or diseases that injure or destroy orchard trees; that this is more important than to expend the necessarily limited energy of the officials in combating pests that affect merely or mainly the fruit. It is objected by some that it is practically impossible to compel an unwilling person to carry out any compulsory treatment properly, and by others that, even if compulsory treatment for such pests as codling moth and apple scab is enforced, it will not to an appreciable degree make it cheaper for orchardists in general to raise first-class fruit. In short, it is argued that the law can not be fully enforced, and that it makes very little difference if it is. But these difficulties remain whether we consider only tree-injuring or only fruit-injuring pests. After all, the exercise of wise discretion on the part of the officers of the law would seem to be necessary. In any case it would seem wise to endeavor to prevent the spread of a new disease or insect as much as possible. So far as well-established enemies are concerned, it would appear to be wisest to enforce the law only where there is a reasonable hope of exterminating them or confining their spread.

INSECTICIDES AND THEIR PREPARATION.

Two general classes of insecticides are commonly used in spraying, namely, those which kill by external contact and those which kill by internal poisoning. The former are used almost exclusively against such insects as plant lice and scale insects, which obtain their nourishment from the plant by means of sucking beaks. The latter are useful only against insects which obtain their food by biting or gnawing.

Attention to these fundamental differences will prevent the mistake too frequently made of spraying with Paris green or similar poisons for such insects as plant lice or the San Jose scale.

Of contact or external insecticides the most important to the Pacific Northwest are the sulphur-salt-lime wash, kerosene emulsion, and whale-oil soap with or without quassia.

Of internal poisons the arsenicals only are used, Paris green being the most common. Paris green is sometimes adulterated, and this, in part at least, accounts for some complaints of nonsuccess attending its use. To be sure that the article purchased is reliable, it is

always well to send a small sample to the chemist of the State experiment station to report upon it.

Recently the arsenic and lime and the arsenic-soda-lime mixtures have been employed by some fruit growers, who report excellent results. Both of these, being cheaper than Paris green, deserve trial, and formulas are therefore given.

THE SULPHUR-SALT-LIME WASH.

Good lime	pounds	40
Sulphur	do	20
Salt	do	15
Water to make	gallons	60

Take 10 pounds of lime and 20 pounds of sulphur, boil with 20 gallons of water for about two hours, or until the sulphur is thoroughly dissolved and the mixture is of deep amber color. While boiling, the liquid must be stirred frequently. Next, place in a cask the rest of the lime and pour enough hot water over it to thoroughly slack it, and while it is still boiling add the salt and stir until it is thoroughly dissolved. Then add this to the lime and sulphur solution in the boiler and boil for another hour. Sufficient water to make 60 gallons should then be added, keeping the mixture well stirred meanwhile. As the solution must be kept well stirred when spraying, it is best to use a pump with an agitator.

This spray is to be used only in the winter, when the leaves are off the trees, and is most effective when applied hot. The trees should first be well pruned, and the spray applied thoroughly, care being taken that no part of the tree, not even one of the smallest twigs, does not receive its coating of the wash.

This is the standard winter wash on the Pacific coast for the San Jose scale. It will also destroy the eggs of the green aphis and the red spider. As a fungicide the mixture has but small value. Some orchardists add concentrated lye to the above solution in the proportion of 2 or 3 pounds to the hundred gallons, claiming that the wash is made much more effective thereby. As it is completely effective without the lye, the addition of the latter seems unnecessary, and no careful experiments have yet been made which demonstrate that the lye is a desirable addition.

The formula as above given is the standard one as at present used. In its manufacture some orchardists slake all the lime, adding the sulphur and salt immediately, and then boil for three hours. There appears no reason to believe that the resulting compound is any different from that obtained by the ordinary method.

Up to the present very little experimenting has been carried on to determine whether modifications of this wash are as effective or more

effective, and there is room for much investigation in this direction. The modification known as Oregon winter wash, in which bluestone is used to replace the salt, has been somewhat extensively used. This was supposed to be virtually a mixture of sulphur-salt-lime and Bordeaux, but chemically, at least, it is not. Theoretically, it would seem that an actual mixture of the two sprays would be better. In places where it is necessary to spray for both the apple scab and the San Jose scale, a series of experiments to test the double efficacy of such a mixture is desirable. Where the San Jose scale occurs, present experience indicates that sulphur-salt-lime is the best spray. Where a fungus alone is sprayed for, Bordeaux is probably the best fungicide.

KEROSENE EMULSION.

Kerosene	gallons	2
Whale-oil soap (or 1 quart soft soap)	pound	½
Water	gallon	1

Dissolve the soap in the boiling water and while still hot add to the kerosene, taking care to keep the latter away from the fire. The whole mixture is then violently agitated, preferably by being pumped back on itself through an ordinary one-eighth-inch nozzle. Many forms of spray pumps answer the purpose admirably. After four or five minutes pumping the mixture will have a thick creamy consistency, and if well made will stand indefinitely without free oil rising to the surface.

One quart of soft soap may be used instead of the one-half pound of hard soap.

Unless otherwise stated, the emulsion is to be used dissolved in water in the proportion of 1 gallon of the emulsion to 15 to 20 gallons of water.

PARIS GREEN OR LONDON PURPLE.

Paris green or London purple	pound	1
Lime	do	1
Water	gallons	150

Make a fine paste of the Paris green or London purple with a small quantity of water, and then add to the lime which has been slaked in a bucket. Pour the mixture through a strainer into the spray tank and add the water.

In some cases, notably for cabbage worms, the poison is better applied dry. For this purpose 1 pound of the poison is mixed with 50 pounds of flour, air-slaked lime, or dust, care being taken to make the mixture very thorough. This is to be applied to the plants, preferably in the early morning, when they are wet with dew. It may be dusted on by sifting through a piece of coarse cheese cloth, or by means of special apparatus made for the purpose.

ARSENIC AND LIME.

White arsenic	pound	1
Lime	pounds	2
Water	gallons	2

Boil the above ingredients for three-fourths of an hour. For use, dilute by adding 300 to 400 gallons of water.

Additional lime in the solution may be necessary to prevent burning of the foliage.

ARSENIC, SODA, AND LIME.

White arsenic	pound	1
Sal-soda crystals	pounds	4
Water	gallons	2

Boil the above ingredients for fifteen to twenty minutes, when the arsenic should be dissolved, leaving only a little sediment. This stock solution may be kept indefinitely, but should be labeled "poison."

To prepare the spraying mixture add 1 quart of the stock solution to 40 gallons of water in which 2 pounds of fresh lime has been dissolved.

Another formula which has been much used by some orchardists, notably, Hon. E. L. Smith, of Hood River, Oreg., is as follows:

White arsenic	pound	1
Sal soda[a]	pounds	2
Water	gallons	2

To prepare the spraying mixture, slake 6 to 8 pounds of lime in 50 gallons of water. Add to this 1½ pints of the stock solution, stir thoroughly, and the mixture is ready for use. The results are claimed to be fully equal to those attained with Paris green.

In employing either of these formulas use great care. The pots and utensils used in preparing the solution should not be employed for other purposes. The arsenic should be plainly labeled, lest it be mistaken for something else.

WHALE-OIL SOAP AND QUASSIA.

Quassia chips	pounds	8
Whale-oil soap	do	7

Soak the chips twelve hours in 8 gallons of water. Dissolve the soap in boiling water. Strain the quassia extract to remove the chips and add the soap solution. Stir thoroughly and dilute to make 100 gallons.

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[a] The dry sal soda should be used in this formula. If the crystal sal soda is used some of the arsenic will remain free and may burn the foliage, as 1 pound of arsenic combines with 1.6 pounds of dry sal soda, or 4.4 pounds of the crystal sal soda. If the crystal sal soda is used it should be increased to 4 pounds, or the spraying mixture should stand for an hour or two in order to allow the arsenic to combine with the excess of lime. L. O. H.

This solution is used almost exclusively for the hop aphis. It is quite as effective against other species of aphis.

The whale-oil soap without the quassia is of somewhat less efficiency.

FUNGICIDES, AND HOW TO PREPARE THEM.

Fungicides are mainly preventive in their effects, a fact that should never be forgotten. Their beneficial action is to prevent the growth of the fungus and the germination of the spores. When the fungicide has been washed off by rain or otherwise removed, the prompt appearance of the fungus may be expected, as rarely or never are the spores destroyed. The most important fungicides are sulphur and its compounds, and the copper salts. In orchard operations sulphur is used mainly for the grape mildew, ordinary commercial sulphur being dusted on the vines. Of the copper sprays, Bordeaux mixture is by far the most important and practically the only one employed in the Northwest.

The following description of methods to be used in preparing fungicides is quoted from Farmers' Bulletin No. 38, Spraying for Fruit Diseases, prepared by B. T. Galloway, of the U. S. Department of Agriculture:

BORDEAUX MIXTURE.

All things considered, it is believed that the best results will be obtained from the use of what is known as the 50-gallon formula of this preparation. This contains—

Water	50 gallons.
Copper sulphate	6 pounds.
Unslacked lime	4 pounds.

It has been found that the method of combining the ingredients has an important bearing on both the chemical composition and physical structure of the mixture. The best results have been obtained from the use of the Bordeaux mixture made in accordance with the following directions: In a barrel or other suitable vessel place 25 gallons of water. Weigh out 6 pounds of copper sulphate, then tie the same in a piece of coarse gunny sack and suspend it just beneath the surface of the water. By tying the bag to a stick laid across the top of the barrel no further attention will be required. In another vessel slack 4 pounds of lime, using care in order to obtain a smooth paste, free from grit and small lumps. To accomplish this it is best to place the lime in an ordinary water pail and add only a small quantity of water at first, say a quart or a quart and a half. When the lime begins to crack and crumble and the water to disappear, add another quart or more, exercising care that the lime at no time gets too dry. Toward the last considerable water will be required, but if added carefully and slowly a perfectly smooth paste will be obtained, provided, of course, the lime is of good quality. When the lime is slacked add sufficient water to the paste to bring the whole up to 25 gallons. When the copper sulphate is entirely dissolved and the lime is cool, pour the lime milk and copper sulphate solution slowly together into a barrel holding 50 gallons, as shown in figure 1. The milk of lime should be thoroughly stirred before pouring. The method described insures good mixing, but to complete this work the barrel of liquid should receive a final stirring, for at least three minutes, with a broad wooden paddle.

It is now necessary to determine whether the mixture is perfect—that is, if it will be safe to apply it to tender foliage. To accomplish this, two simple tests may be

used. First insert the blade of a penknife in the mixture, allowing it to remain there for at least one minute. If metallic copper forms on the blade, or, in other words, if the polished surface of the steel assumes the color of copper plate, the mixture is unsafe and more lime must be added. If, on the other hand, the blade of the knife remains unchanged, it is safe to conclude that the mixture is as perfect as it can be made. As an additional test, however, some of the mixture may be poured into an an old plate or saucer, and while held between the eyes and the light the breath should be gently blown upon the liquid for at least half a minute. If the mixture is properly made, a thin pellicle, looking like oil on water, will begin to form on the surface of the liquid. If no pellicle forms, more milk of lime should be added.

If spraying is to be done upon a large scale, it will be found much more convenient and economical in every way to prepare what are known as stock solutions of both the copper and lime. To prepare a stock solution of copper sulphate, procure a barrel holding 50 gallons. Weigh out 100 pounds of copper sulphate, and after tying it in a sack suspend it so that it will hang as near the top of the barrel as possible. Fill the barrel with water, and in two or three days the copper will be dissolved. Now remove the sack and add enough water to bring the solution again up to the 50-gallon mark, previously made on the barrel. It will be understood, of course, that this

FIG. 1.—Making Bordeaux mixture; Pouring together the lime milk and copper sulphate solution.

second adding of water is merely to replace the space previously occupied by the sack and the crystals of copper sulphate. Each gallon of the solution thus made will contain 2 pounds of copper sulphate, and, under all ordinary conditions of temperature there will be no material recrystallization, so that the stock preparation may be kept indefinitely.

Stock lime may be prepared in much the same way as the copper sulphate solution. Procure a barrel holding 50 gallons, making a mark to indicate the 50-gallon point. Weigh out 100 pounds of fresh lime, place it in the barrel, and slack it. When slacked, add sufficient water to bring the whole mass up to 50 gallons. Each gallon of this preparation contains, after thorough stirring, 2 pounds of lime.

When it is desired to make Bordeaux mixture of the 50-gallon formula it is only necessary to measure out 3 gallons of the stock copper solution, and, after thorough stirring, 2 gallons of the stock lime; dilute each to 25 gallons, mix, stir, and test as already described. One test will be sufficient in this case. In other words, it will not be necessary to test each lot of Bordeaux mixture made from the stock preparations, provided the first lot is perfect and no change is made in the quantities of the materials used. Special care should be taken to see that the lime milk is stirred thoroughly each time before applying. As a final precaution it will be well to keep both the stock copper sulphate and the stock lime tightly covered.

AMMONIACAL SOLUTION OF COPPER CARBONATE.

This preparation, as now generally used, contains—

Water	45 gallons.
Strong aqua ammonia	3 pints.
Copper carbonate	5 ounces.

The copper carbonate is first made into a thin paste by adding a pint and a half of water. The ammonia water is then slowly added, and if of the proper strength, i. e., 26 degrees, a clear, deep-blue solution is obtained, which does not become cloudy when diluted to 45 gallons.

The ammoniacal solution of copper carbonate being a clear liquid, its presence on the leaves, fruit, and other parts of the treated plants is not so noticeable as where the preparations containing lime are used.

In case it is desired to keep the strong solution as a stock preparation, the bottle or jug in which it is placed should be tightly corked.

In spraying the apple and pear for codling-moth and scab, time and expense may be saved by combining the sprays. In this case Paris green is added directly to the Bordeaux, using 1 pound of the poison to 150 gallons of the Bordeaux; but of course the Paris green is not to be used with the Bordeaux in the sprayings which are applied before the trees blossom.

The arsenic-lime and arsenic-soda-lime compounds may be used in the same way. In making such spraying mixtures, the Bordeaux solution is always to be considered as replacing the water, in making calculations.

QUACK INSECTICIDES AND FUNGICIDES.

There are always upon the market various sorts of patent spraying compounds and nostrums, which agree in one respect only, and that is in being recommended as a perfect remedy for every insect and fungus that ever attacks plants.

While several of these compounds have more or less merit, none of them thus far tested are equal to the standard sprays. For the most part they are decidedly more costly and decidedly less effective.

Two classes of these compounds need especial mention and condemnation:

CURE-ALL REMEDIES.

These are mixtures of almost every conceivable substance that has ever been used with the slightest degree of success. One such has been advertised as containing whale-oil soap, arsenic, copper sulphate, tar, green vitriol, and sulphur, but as a matter of fact some of these were not present. A vital objection to such "shotgun" remedies, even if they possess real merit, is their greater cost. Anyone can see that when arsenic is the desired insecticide the others are useless, and the same might be said of nearly every ingredient in turn. The idea of the manufacturer seems to be that the average farmer has not intelligence enough to make standard sprays, and hence is glad to

purchase one that can be used against every enemy which may attack his trees. The apparent commercial success of some of these manufacturers seems to show that the farmer, like most of his fellows, needs to be warned against humbugs.

SAP POISONS.

An enticing idea to everyone that owns a tree is that it may be made immune to insects and fungi by putting some compound at its roots, or preferably in a hole bored in the trunk. Copper sulphate, either alone or mixed with other substances, seems to be a favorite remedy with people who accept the idea. Recently a mixture of this sort has been widely advertised. On analysis it was found to contain copper sulphate, bone charcoal, sulphur, and some washing powder. The charcoal and sulphur, which are insoluble in water, made up most of the mixture.

The theory of such remedies is to poison the sap of the tree so that insects will either be poisoned by it or else dislike its taste, and fungi will be unable to thrive on account of it. The unfortunate flaw in the theory is that copper sulphate is quite as poisonous to the trees as it is to the pests, and a sufficient quantity of it to have the desired effect would result disastrously to the tree.

Faith in these supposed remedies would be largely destroyed if farmers would test them impartially. For example, in a horticultural meeting not long since a farmer declared that copper sulphate placed at the roots of young trees protected them from aphis attacks. He had treated thus every tree in his orchard the year before, and not one was attacked by that insect, which proved to him that the copper sulphate repelled the aphides. As a matter of fact, it did not prove this. The thing was just as well and probably more truly explained by its not being an "aphis year." If the farmer had treated all his orchard save a series of check trees here and there throughout the orchard, and the check or untreated trees had been attacked, while the treated trees were free from the insect, he would have had strong evidence in favor of the truth of his idea. Without such check trees by which to compare results, any series of experiments is of little value, because the results can not be clearly interpreted. If farmers would bear this fundamental part of every experiment in mind, there would soon be less success too in the quack insect-destroyer business.

INSECT PESTS.

In the following paragraphs the principal insects affecting orchards in the Pacific Northwest are briefly described, their habits are outlined, and the proper remedies are named:

SAN JOSE SCALE.

So well known has this destructive insect become that most orchardists are familiar with it. Its presence in an orchard is usually first

discovered during fruit picking. On apples and pears especially the presence of the scale is at once disclosed by the bright red ring-like spots which surround the places where the scales are attached to the fruit. No other scale insect does this; so that this peculiarity makes identification easy and certain. Red spots sometimes appear on fruit from other causes, but in such cases, of course, no scale insect will be found at the center. This fact is an important one, because it enables a fruit grower to discover promptly not only when his orchard becomes infested, but the exact trees which are attacked.

When the scales are abundant they completely cover the trunk and branches, giving them a characteristic grayish mealy appearance. On scraping such a twig a yellowish oily fluid will be seen, which comes from the crushed bodies of the insects. Cutting a strip of the bark will reveal a reddish discoloration, which may also extend to the wood.

The San Jose scale is at once distinguished from other related pests by the small size of the scales, which measure commonly about one-sixteenth of an inch in diameter, though rarely specimens may be found nearly an eighth of an inch across. The scales are circular and somewhat elevated in the middle, which bears a small black or yellowish pointed process. In badly infested orchards they completely cover the trees, giving the branches an unhealthy, grayish, scurfy appearance.

In winter the scales are to be found only in half or nearly full grown condition, and completely dormant. With the first flow of sap in spring they begin to feed again, and become fully grown in May and June, when the first brood of larvæ is produced. So far as known, all these larvæ are born alive. They move about actively for a few hours or even a day or more, finally settling on tender twigs, leaves, or fruit, into which they gradually insert their beaks and begin to suck juices from the plant.

From this time on broods are produced incessantly through the summer, and the insect can be found in all stages until late in October. Shortly after settling on a spot the larva secretes a waxy substance, the beginning of the formation of a scale.

Description.—The following description is quoted from Dr. L. O. Howard, Entomologist, U. S. Department of Agriculture:

In two days the insect becomes invisible, being covered by a pale grayish-yellow shield, with a projecting nipple at the center. This nipple is at first white in color. Twelve days after hatching the first skin is cast. The males at this time are rather larger than the females, which have large purple eyes, while the females have lost their eyes entirely. The legs and antennæ have disappeared in both cases. Six days later the males begin to change to pupæ, while the females have not yet cast their second skin. At this time the females are so tightly cemented to the scale that they can not be removed without crushing. In two or three days more, or twenty to twenty-one days after hatching, the females cast their second skin, which splits around the margin of the body. At twenty-four days the males begin to issue,

emerging from the scales as a general thing at night. At thirty days the females are fully grown, and embryonic young can be seen in their bodies, and from thirty-three to forty days the larvæ begin to make their appearance.

The adult male is a delicate two-winged creature, bearing a straight stoutish appendage at the posterior end. It lives in this adult condition but a short time. The female never attains wings or leaves the scale after it is once formed.

Only in the active larval condition can the pest become spread. This is greatly facilitated by the habit of the larvæ of crawling on other insects or on the feet of birds, and being thus carried from tree to tree.

Remedies.—The sulphur-salt-lime wash applied in winter is a completely effective remedy on the Pacific coast. The ordinary practice in the Northwest is to spray in late winter after pruning. Care should be taken to spray every branch even to the very tip. If only a few of the insects escape, the whole tree may be again covered with them before the fruit is mature.

THE CODLING MOTH.

Fortunate, indeed, is the orchardist who does not know this insect from actual experience, yet there are portions of the Northwest where it is yet unknown.

The insect is the common "worm" of the apple and pear, and in the orchard may be easily detected (1) by the brownish castings which are thrust out of its burrow and then cling to the side of the fruit and (2) from the fact that many of the injured fruits fall prematurely to the ground.

Description and habits.—The larva is the young of a small purplish-brown moth, which measures a little more than half an inch from tip to tip. The first moths usually appear shortly after the apple trees are in bloom, but in the warmer regions they may appear before the blossoms open. The females deposit their eggs usually on the young apples, one or two in a place, and are capable of laying 40 or 50 eggs. In from six to eight days these eggs hatch into minute larvæ or "worms," which soon burrow into the young fruit, usually at the blossom end. Reaching the core when half grown, the larva eats out an irregular cavity, and sometimes may be found eating the seeds. The castings are thrown out through the hole by which the worm entered, or when the larva is full-grown and about to leave the apple, through a horizontal hole bored to the side. These castings are of a rusty reddish color and make the wormy apples quite easy to detect at this time. In about three weeks the larva reaches its full size and then leaves the fruit, either by crawling out of the hole and thence onto the tree or by dropping to the ground on a silken thread which it spins; many of the injured fruits drop to the ground, and not rarely this happens before

the larva has attained its full growth. In such case the worms crawl out of the fruit almost immediately.

The larvæ seek for protected places, such as crevices in the bark or cracks in the soil, and there spin thin cocoons, in which they soon change to brownish pupæ. In from twelve to twenty days the adult moths emerge, and a few days later eggs are laid from which a second brood of larvæ develops.

The larvæ of the second brood are peculiar in that they usually enter the fruit from the side, a favorite place being where apples touch. In most sections this second brood is quite distinct from the first in time of appearance, and the larvæ for the most part hibernate over winter. In the warmer valleys, however, there is a continuous succession of individuals from the first to the second broods, and even until the crop is harvested the insect may be found in every stage. This has usually been interpreted as indicating the existence of three or more broods.

The larvæ of the last brood in the year hibernate over winter in silken cocoons, and change into pupæ the following spring. The moths are rarely seen unless specially looked for or reared from pupæ. They fly mostly in the evening, and are not attracted to lights.

Remedies.—Spraying with the arsenicals is by far the most satisfactory means of combating this insect. The most important application is the first, which should be applied as soon as the petals fall from the blossoms, but not before. A prime object is to have the blossom end of the young pear or apple filled with the poison, as this is where the worm usually enters. In order to do this the fruit must be sprayed before the calyx cup at the blossom end closes, which is shortly after the fruit sets. Some growers spray the solution with considerable force, claiming that it yields better results by getting more poison in the calyx cup. A second spraying, about two or three weeks later, seems always profitable. The value of either of these sprayings may be completely destroyed by heavy rains following the application, in which case they will need to be repeated at once.

These two sprayings are all that are necessary in the greater part of the Coast region and in the inland uplands. In the warm inland valleys, however, more sprayings are required. Different growers apply these later sprayings at somewhat different dates. The third spraying is commonly given about July 10 to 15, the others at intervals of three weeks, the last in September.

In addition to spraying, some growers, especially in the warmer valleys, use the "banding system" as an additional means of protection. In this practice advantage is taken of the habit of the larvæ of seeking sheltered places in which to pupate. The simplest way is to fasten a strip of burlap around the trunk of the tree a foot or so above the ground. The burlap should reach around the trunk, and is conveniently fastened with a nail. If the trunk of the tree is clean and

free from loose bark most of the larvæ which escape the spraying will pupate beneath the burlap band and may there easily be killed. Where this system alone is depended on the bands are examined every ten or eleven days, because if a longer time elapses many of the moths will emerge. This practice alone is by no means as efficient as spraying alone. It would seem that, in any case, it would be desirable to use the bands to trap as many as possible of the last brood each year, thereby lessening the injury from them the following spring.

THE PEACH TWIG-BORER.

This insect injures the peach in two very different ways, namely, by burrowing into the fruit, making the so-called "wormy" peaches, and by boring into the twigs, which it frequently kills.

Description and habits.—The insect is usually noted in gathering the later varieties of peaches, the earlier ones being quite exempt, as a rule. The worm enters at the stem end, and usually bores into the seed, which it seems to prefer. In such cases the stone usually splits as the fruit ripens. At other times the worm burrows only through the flesh, making irregular tunnels. Whether the seed is attacked or not seems to depend on how far the stone has hardened when attacked. The larva is pinkish or dirty brown in color, about one-half an inch long, and very commonly changes into a pupa inside the split stone.

The adult is a small, dark-gray moth, marked on the fore-wings with a few dark spots and streaks. Both pairs of wings are bordered with a paler fringe. These adults issue in August and later, and lay their eggs in or near the crotches of the branches. When the eggs hatch, the young burrow into the bark in the crotch and feed on the soft, spongy bark until the succeeding spring. Their presence during the winter is disclosed by the fine brownish castings which are thrown out and become heaped up at the entrances to the burrows. Just as the leaves are developing in the spring they leave their winter quarters, and for a short time feed on the tender shoots. They bind the young leaves together loosely with silk threads, and later, when some of these leaves or the whole twig turns brown from the injuries, the work of the insect is very conspicuous.

At this time, however, the larva has usually left the leaves, and in some secluded place transforms into a pupa. From this the moth soon emerges and lays the eggs from which hatches the brood which attacks the fruit. According to Marlatt it is a third brood and not the second which enters the fruit.

Remedies.—Excellent results have been reached in Snake River Valley by spraying the trees in winter with kerosene emulsion, used preferably somewhat less diluted than for ordinary purposes. The castings at the mouths of the winter burrows readily absorb the oil, which penetrates into the holes and destroys the worms.

The sulphur-salt-lime wash has no appreciable effect on the insect.

THE WESTERN PULVINARIA OR COTTONY SCALE.

This insect is considered to be merely a variety of the Eastern cottony maple-scale, but it is very different in its food plants. While the Eastern insect attacks only the maple, the Western variety never is found on maples but has quite a long list of host plants, namely, currant, gooseberry, pear, mountain ash, lilac, alder, poplar, hawthorn, and willow. So far as known the life history is as follows:

During May and June the female lays the eggs in large numbers in a mass of white waxy fibers secreted from the posterior end of her body. As the eggs develop they expand the waxy mass and raise the insect's body to a considerable angle to the twig on which it is attached. If the waxy mass is crushed at this time blood-colored streaks appear, arising from the eggs and the bodies of the young larvæ which hatch from the eggs. These larvæ resemble lice and run about over the plant actively. About the time the last eggs are laid the female dies, but the tough leathery scale and the fluffy mass of fibers cling to the twig for a long time.

The young insects settle themselves on young twigs, insert their beaks, and begin to suck sap. They increase in size rapidly, after having covered themselves with tough waxy substance for protection, and reach their full size in August. About this time the male insects, which are narrower than the females, change into pupæ and soon after emerge as delicate two-winged creatures. After a few days' life, in which they pair with the female, they perish.

The females never become winged and seldom leave the branch on which they are born. After the flow of sap ceases they become dormant until the following spring.

As the female never acquires wings it seems at first sight difficult to account for the spread of the insect. Perhaps the most effective means of spreading the insect has been by infested nursery stock, as the insect is inconspicuous in winter. No doubt birds now and then carry the active young larvæ, which have crawled upon them, for considerable distances. Only thus can the fact be explained when the insect is found on a wild tree some distance from the nearest garden.

Remedies.—Spray during May and June with kerosene emulsion or whale-oil soap solutions, the aim being to destroy the young larvæ. Two sprayings are necessary, the first about the time the cottony mass is most conspicuous, the second a week or ten days later. On currant and gooseberry bushes the first spraying would be at the time the fruits are fully grown but before they have begun to ripen; the second spraying may be deferred until the crop is picked.

Winter spraying with the sulphur-salt-lime wash or with a strong solution of whale-oil soap, using 1½ or 2 pounds of the soap to a gallon of water, would doubtless prove completely effective, but so far as we know the actual experiment has not been carried out.

THE GREEN APHIS OF THE APPLE.

Description and habits.—In winter a sharp inspection of the apple trees in the orchard will usually reveal the fact that some of them have their twigs literally covered with shiny black oval eggs, large enough to be seen easily with the naked eye. About the time the leaves develop in the spring these eggs hatch, and, curiously enough, all of them give rise to females. These females are peculiar in that after a few days they give birth to living young, and this without having been fertilized. They are, therefore, called agamic or virgin repro ducing females. Similar broods follow each other quickly throughout the summer, and reproduce with wonderful rapidity. All of these summer broods, like the first, are composed of agamic females. Some of the broods are wholly or in part winged, and such spread the pest to other trees or orchards. As cold weather approaches there is produced a brood of perfect males and females. The latter lay the fertilized winter eggs by which the life of the insect is tided over to the following spring.

This insect varies in its abundance from year to year, and some places are much more troubled with it than others. In most orchards only a small portion of the trees are attacked, the insect seeming to pick out the weak or sickly ones especially. The damage done is not very great, but the attacked trees are unsightly on account of their distorted leaves and the dirty-black appearance caused by the excretions of the aphides.

Natural enemies.—On an aphis-infested tree are always found many other insects. The lady birds and lace-wing flies feed on the aphides and destroy great numbers of them. Ants are attracted and feed on the honey dew which the aphides excrete from two tube-like processes on their backs. It is a popular mistake that the ant destroys the green aphis. This is not the case. Besides the above, many other insects are found. Some are parasites of the aphides, but most of them are attracted by the honey dew.

Remedies.—It pays to search out in the winter the trees which are covered with eggs, and either to cut off the infested twigs or to spray the tree with sulphur-salt-lime, which kills the eggs. It does not pay to winter-spray a whole orchard for this insect, as is sometimes done.

Perhaps the most satisfactory method of controlling this insect is to spray with kerosene emulsion after the insects appear and before the leaves curl up from their attacks. It may be necessary to spray several times during the summer.

The same method is the best one for combating other species of aphis which attack trees.

THE WOOLLY APHIS OF THE APPLE.

Description and habits.—This insect exists in two forms, one of which attacks the roots, the other the trunk and the branches of apple trees. A great majority of the individuals are wingless, but winged ones also occur, especially in the later broods of the year. The species derives its name from a peculiar white fluffy substance which exudes from the insects' bodies, making them appear as though covered with cotton, and rendering them very conspicuous on the trees. They are especially liable to be abundant on the suckers from the bases of trees and in the forks of the branches. The cottony covering serves to some extent as a protection, so that this species is rather more difficult to kill than other aphides.

The root form of insect is the more injurious. By its attacks peculiar galls are formed on the roots, in the crevices of which the lice may be found. These galls not only interfere seriously with the functions of the roots, but also form centers of decay, and may cause the death of the tree.

The branch form weakens the tree by feeding on the sap, and not infrequently causes the bark to split in places as the result of its attacks; it never forms true galls like the root form. The entire life of the woolly aphis is spent on the apple tree, the winter eggs being laid in sheltered crevices.

It must be understood that the two forms differ mainly in their mode of life. The presence of either form will sooner or later give rise to the other, and badly infested trees are sure to be attacked both on the roots and on the branches.

This insect is most abundant in the Coast region. In Washington the writer has frequently searched for the root form without success. Professor Cordley reports it from the Willamette Valley.

Remedies.—This pest is far more likely to be introduced on nursery stock than in any other way. The roots of purchased apple trees should always be examined for the galls of this insect; if the galls are large or numerous, *reject the trees.* If they are small and few, they may be completely disinfected by dipping the roots in kerosene emulsion or in hot water (120°–140° F.) for a moment. If trees in the orchard are attacked by the root form, the soil should be removed as much as possible from them and the roots thoroughly treated with kerosene emulsion or with water heated nearly to the boiling point.

For the branch form, spray with kerosene emulsion, using rather stronger solutions than for other aphides.

The root galls caused by this insect should not be confounded with those of the crown-gall disease described elsewhere. Trees infested with the latter disease can not be disinfected by any known means. The safest rule is not to accept any trees with galls on the roots.

THE PEAR-LEAF BLISTER-MITE.

The presence of this pest is readily known by the bright red pimple-like spots that appear on the young leaves. Later these spots turn green and then brownish, forming cork-like thickenings on the under sides of the leaves. The cause of the spot is a minute four-legged mite, scarcely visible to the naked eye, and measuring but one one-hundred-and-fiftieth of an inch long. Its body is cylindrical in form and marked crosswise by numerous fine striæ. As soon as the leaves burst from the buds in spring the mites burrow into them, forming the bright red galls, which are hollow and have minute openings on the under sides of the leaves. In these galls eggs are laid, which soon hatch into young mites. As fast as new leaves come out the mites migrate to them, forming new galls, and this process continues as long as leaves are developed. Before the leaves fall in autumn the mites crawl back to the twigs and pass the winter in cracks in the bark and similar places, but more particularly beneath the scales of the winter buds. At no stage of the mite's life is it able to move fast, but the pest becomes spread from tree to tree by crawling on insects, the feet of birds, and probably in other similar ways. The damage done is sometimes quite severe, as the function of the leaves is seriously impaired by their attacks. The affected leaves also fall prematurely.

Remedies.—Experiments with this pest have not been very satisfactory. Spraying in winter when the mites are under the bud scales with kerosene emulsion *diluted only three times* gave the best results, but this strength also injured the trees somewhat. In no instance were all the mites destroyed. Protracted periods of cold weather are fatal to the pest, and it was almost exterminated in the inland region during the winter of 1898–99.

BACTERIAL AND FUNGOUS DISEASES.

BLACKSPOT APPLE CANKER.

Description.—This disease has been demonstrated by Newton B. Pierce to be caused by a fungus which has recently been named by Peck, *Macrophoma curvispora*, and later by Cordley as *Malicorticis glœosporium*. As the disease is unknown save in the Coast region of the Northwest, it is in all probability native, though it has not yet been found on wild trees. Apparently it attacks only the apple. Similar but far less serious diseases occur on both the pear and prune. The blackspot disease is confined to the bark, and derives its name from the characteristic dark brownish or nearly black spots which it causes. These spots appear only on smooth bark in which no cork has developed. Hence on old trees they are found only on the branches and twigs, but on young trees occur everywhere, being usually most

numerous on the trunks. The spots appear mostly in fall and winter, from November until January. They may easily be detected when no larger than a pin head. They increase quite rapidly in size and at the same time grow deeper, penetrating through the bark into the sap wood beneath, as evidenced by the brownish discoloration.

Nature of injury.—Almost from the first the spots are slightly sunken below the surrounding healthy bark, a fact evidently caused by the death and shrinking of the tissue. When the spots have attained their full dimensions, which occurs in February and later, the epidermis of the bark at the edge of the discolored spot commonly bursts. Still later in the season this deepens into a crack, which sharply separates the diseased from the healthy tissue. When once this crack has appeared the limit of the growth of the spot is reached, and beyond this limit it never spreads. The mature spots vary greatly in size and shape. Ordinarily they are oval, from 1 to 3 inches long and about half as wide; quite commonly two or more spots merge together, and not rarely girdle the trunk or branch. Sometimes the diseased areas are from 1 to 2 feet in length and completely girdle the attacked branch for the whole distance. On small twigs a similar girdling is very common.

When the spots are six months or more old numerous pustules as large as a pin head or larger burst through the dead epidermis. At first these pustules are whitish from the numerous spores borne on their surfaces, but as the spores fall off they become blackish. These spores are curved, colorless, about one-sixteen-hundredth of an inch long and one-fourth of that in width, and are borne singly on stalks as long as the spores. These spores are blown about in the air and by them the disease is spread. A spore will germinate readily in water, sending out a germ tube which later becomes branched into a mycelium. In nutrient substances this mycelium bears numerous secondary spores from the ends of short lateral branches. Under natural conditions these secondary spores seldom occur. The primary spores are able directly to give rise to new spots on healthy bark, the germ tubes apparently entering through a lenticel. This then completes the life history of the fungus as it occurs under natural conditions.

About the time the spores become mature the dead bark has usually separated from the wood beneath, being uplifted by the surrounding growing bark and wood, and sooner or later falls off, leaving the characteristic scars of the disease. When these scars are small and few, the new wood and bark may in time completely cover them. Unfortunately the spots are usually numerous enough to partially girdle the tree and so seriously weaken it as to make it almost worthless. Not rarely the trunks of young trees or the branches of older ones are completely girdled, which necessarily results in the death of all parts above such injury.

Remedies.—When the disease first appeared a common practice was to cut out the diseased spots while small and to paint over the resulting wounds. This was practicable only on the trunks of young trees, and where the spots were few was fairly satisfactory. When, however, a young tree trunk has dozens or even hundreds of such spots the remedy is nearly as bad as the disease, besides being extremely laborious. On the branches of old trees such a method is utterly impracticable.

From the foregoing account of the disease it is evident that the time when the tree needs protection most is from November 1 to February 1, and perhaps even later; at any rate, this is the period when most of the spots begin. Apparently such a fungicide as Bordeaux mixture should protect the trees during the period. The greatest difficulty arises from the fact that even Bordeaux mixture will not withstand the frequent fall and winter rains which prevail, unless applied several times. An ideal remedy would be a solution as effective as Bordeaux mixture for fungicidal purposes, and which would not wash off as readily. Experiments to discover such a wash if possible are now in progress.

APPLE SCAB.

Description.—Scab is without doubt the most destructive fungous disease in the Coast region. It commonly attacks both the leaves and the fruit, and sometimes occurs on young twigs as well. On the fruit the fungus forms circular spots of a dark smoky green or nearly black color, usually marked at the edge by a pale line where the skin of the apple is slightly raised. These spots begin to appear when the fruit is half grown, or even earlier. Single spots may reach the size of a dime, but ordinarily they are smaller. When close together they frequently unite and may thus occupy a considerable area. The effect of the fungous spot is to retard the growth of the apple tissue in its immediate vicinity, and when a number of spots are close together the apple becomes more or less distorted on that side. Where several spots merge together, irregular radiating cracks may appear.

On the leaves the fungus appears as dark olive green spots which are not sharply limited. They occur mostly on the upper side of the leaf, which may, indeed, be completely covered. The growth of the apple leaf where the spots occur is much hindered, so that the leaves are more or less curled or hummocky.

Microscopic examination of the fungus either from the leaves or fruit reveals that the part of the fungus seen consists of short upright stalks, each of which bears a single oval or spindle-form spore, which may or may not be divided by a cross partition. These spores float about in the air and thus spread the disease.

In comparatively rare cases where the twigs are attacked, the fungus lives over winter and in early spring again produces spores. Ordi-

narily, however, the disease commences in the spring from spores blown off the fallen leaves, or those which lodge in the crevices of winter buds.

Remedies.—In the light of present experience, three sprayings of Bordeaux mixture and two of cupram are necessary to insure a clean crop in the Coast region. The first spraying of Bordeaux should be just before the blossoms open, the second just after the petals fall, and the third ten or twelve days later. The two sprayings of cupram should follow the last spraying of Bordeaux at intervals of two weeks. Bordeaux should not be used for the fourth and fifth spraying, as it causes fruit to russet.

It is always good practice to prune the tops of trees, so as to induce an open growth. In such trees the apple scab causes conspicuously less damage than in dense ones.

PEAR SCAB.

This disease is so closely similar to the apple scab that no detailed account of it is necessary. Like the apple scab, it is much more injurious to some varieties than to others. In susceptible kinds such as the Winter Nelis, the twigs are very commonly attacked by the fungus, and in this as well as other varieties a large portion of the blossoms may be killed by the fungus on the flower stalk. This emphasizes the importance of the early sprayings, which are to be applied as recommended for the apple.

BROWN ROT OR FRUIT MOLD.

Description.—This is the only serious fungous disease of the plum, prune, cherry, and peach yet known in the orchards of the Northwest, where it has become introduced within the last few years. Usually the first symptom of this disease to attract attention is the numerous grayish-white pustules that appear on the attacked fruit when it is nearly ripe. The pustules consist of the reproductive bodies or spores of the fungus, and under the microscope are seen to be oval in shape and arranged in rows, like chains of beads. The disease is scattered by these spores being carried by the air currents, or in some cases by insects. Under favorable conditions the spores quickly germinate, sending out a germ tube that will penetrate a healthy fruit and soon cause it to rot. In the laboratory a single spore placed on a plum or cherry will develop so far in twenty-four hours as to produce new spores. From this it is easy to understand why the disease spreads so rapidly in orchards under favorable circumstances. In some cases a whole crop may be destroyed within a few days' time.

A curious feature of this fungus is that it causes the attacked fruit to become dry and hard, in which condition it may remain hanging on the tree for a long time. It is mainly on these fruits that the fungus passes the winter, and on such fruit the spores may be found in abun-

dance in the spring. While the spores will germinate almost immediately after they are formed, they can also withstand hardships, and will grow after they have been kept two years.

The pustules or blisters just described constitute only the reproductive parts of the fungus. In the interior of the fruit may be found innumerable filaments which make up the mycelium or vegetative part of the fungus.

Besides the fruit, the fungus also attacks the leaves, the flowers, and the twigs. When the flowers are affected they become brownish and rotten. In most cases it is through the stalk of the flower that the fungus enters the twig, where it sometimes causes serious damage, especially in the case of peach trees. The mycelium in the twigs lives from year to year, and the fungus may in this way have been introduced into the Northwest. The disease spreads much more rapidly in damp weather than in dry, so that the amount of damage it does is much more serious in some seasons than others.

Remedies.—As the fungus passes the winter mainly on the mummified or dried up fruits, these should always be gathered and burned. This treatment alone will often lessen the loss very materially.

It is also desirable to thin the fruit so that no clusters remain. Where a cluster of fruit is left, it frequently happens that all in the bunch are destroyed.

Spraying has not yielded perfectly satisfactory results with this disease on account of injury to the foliage. Two sprayings of Bordeaux—one just before the blossoms open, the other just after the petals fall—are usually recommended. The second spraying should be made with a Bordeaux containing a large excess of lime. Any later spraying is liable to result in defoliation of the trees.

PEAR BLIGHT.

This disease, which was exceedingly bad in 1899 and 1900 and hardly less so in 1901, may readily be recognized from the fact that the leaves and twigs of attacked branches turn black, giving the tree the appearance of having been scorched by fire, hence the popular designation, "fire blight." As has been fully demonstrated, the disease is caused by a species of bacteria or microscopic organism. As a result of the investigations made by Waite,[a] the life history of this germ and the proper treatment for it are now well understood. The attack usually begins in the blossoms, less commonly in young twigs or young leaves. The disease rapidly works down the cambium layer between the bark and the wood, and the foliage quickly blackens. The leaves are quite often directly attacked by the disease, in which case only portions of them are blackened. It is uncommon for the disease to work down into the twig from the leaf.

[a] M. B. Waite. The Cause and Prevention of Pear Blight. Yearbook U. S. Dept. of Agr., 1895, pp. 295-300.

Besides the pear, the same disease affects the quince and the apple. The apple is, however, quite resistant and rarely suffers injury.

The first appearance of the disease is usually after the flowering time. In 1901, owing probably to the cold weather, the disease did not become noticeable till the fruit was fairly well grown. An attacked branch is always killed and not rarely the whole tree succumbs. If left alone the disease usually continues to go down the branches during the greater part of the summer. Sooner or later, however, it ceases, and in the fall of the year one will find that in a majority of the blackened limbs, where the leaves cling a long time, there is a well-defined line between the dead blackened part and the healthy bark. On these limbs the disease has died out. On the other limbs, especially water sprouts, it will be found that there is no such line of demarcation, but the diseased portions fade insensibly into the healthy ones. On cutting into such a branch it is found to be moist, not dry as in the case of the dead limbs. It is in these comparatively few limbs that the blight germ lives over the winter. With the renewed growth in spring it frequently happens that a slimy sap exudes out of these limbs, which is swarming with the germs of the disease. Flies and bees are attracted to the juice, and then flying to the flowers are almost sure to leave in the honey pit some of the germs which have become attached to their beaks or feet. In the honey of the flower the germs rapidly multiply, and work thence downward into the twigs. As bees are very abundant on trees in flower it may readily be seen how the disease becomes spread.

Culture methods.—A peculiar fact about this disease is that it attacks first the most thrifty trees; slow-grown stunted trees are less liable to it. This fact has been taken advantage of in blight-infested regions by planting the pear and quince trees in very poor soil, thus insuring slow growth and a consequent partial immunity from the disease.

In richer lands the pear orchard should not be cultivated. In irrigated lands no more water should be given the pears than is absolutely necessary. It is well, too, not to prune the trees much, as this tends to force new growth, which is more favorable to the disease. Such methods are of value in the handling of a pear orchard.

Summer pruning.—In any case recourse must be had to cutting out the blight. This should be done as soon as it appears, care being taken to cut off each diseased sprig or branch well below the lowest trace of the blight. If the disease has run down a short lateral to a main branch, the latter must be cut off below the origin of the lateral. If the disease has reached the main trunk the tree is doomed. In this pruning it is quite easy to get the knife or the shears covered with the germs and thus spread the disease each time a cut is made. It is therefore well to dip the knife or shears now and then in a strong solution of carbolic acid, which will destroy any germs that may be on it.

As a result of considerable experience in summer pruning of the pear blight, we are able to say that the common fault is that the limbs are usually cut off too near the part which is diseased. It is best to make the cut at least a foot below the lowest blackening visible. In certain cases the disease may even have spread farther down than this without showing on the surface.

Fall or winter pruning.—This is, after all, the most important method of combating the disease. Examination of pear trees in the early winter will disclose the fact that most of the blighted limbs still have the dead leaves clinging to them, while the healthy limbs are bare. Careful search will also reveal the fact that in most of the limbs the disease has run its course and a sharp boundary line exists between the dead dry bark and the living green bark. It is of no importance whatever whether these dead blighted limbs be removed or not. In them the blight germ has perished and from them there can be no further spreading of the disease. In a very few cases, however, especially in young water shoots, it will be found that the bark is black and juicy, not dry, and that the disease-darkened bark fades gradually into the healthy bark. In these the blight germ is living, and it is in such branches that it survives the winter. If every branch containing living germs could be cut off in winter well below the lowest trace of the disease, pear blight could be exterminated. But a single limb of this kind may infect a whole orchard the following season. It is preferable to burn such branches; but if the pruning is done before February it is not necessary. It is very important, however, to take care that new inoculations of the disease are not made with the pruning knife or pruning shears. Merely cutting into diseased branches and then healthy ones frequently starts new infections; therefore, extreme care must be taken to keep the tool used free from the living germs.

To avoid the danger of losing the whole tree or larger branches the trunk should be kept free of water shoots and the fruiting spurs should be removed from the lower parts of the larger branches as suggested by Waite. If this is not done the blight may run down the short fruit spur and thus destroy a large branch. It is safe to say that 90 per cent of the infections which take place in the flowerless sprouts are probably caused by the punctures of insects which have just visited diseased parts. Experiments indicate that in no case can the blight enter an uninjured leaf or twig.

Virulence of the disease in the Northwest.—The above recommendations are based on the records of Eastern experience with the disease. It must be confessed the three years' experience with the disease in the inland fruit-growing districts of the Northwest have been discouraging. Intelligent use of the knife both in summer and fall will enable one to save his trees, more or less mutilated, however.

It would seem that the disease here is remarkably virulent. At least, the writer has been able to find no records of such wholesale destruction as it has caused in these inland districts. Unless the virulence of the disease should become lessened in the course of a few years, a phenomenon that would not be without parallel, the future of pear growing in these inland areas is not clear.

Some varieties, like Flemish Beauty, are notably more resistant than others, and a bright ray of hope exists in the possibility of transferring this resisting power to other varieties. This, however, will require many years of experimenting.

The Idaho pear is particularly susceptible to blight, and should not be planted in infested districts on that account.

CROWN GALL OR ROOT GALL.

This disease causes galls to appear on the roots of various trees and shrubs. On fruit trees it commonly forms spherical swellings of various sizes, occasionally as large as a walnut. These globular bodies have usually a peculiar warty surface. They should not be confused with the galls formed by woolly aphis, which, moreover, are smaller and usually oval or irregular. Besides in aphis galls some of the "wool" is usually to be found.

It frequently happens that when the roots are affected with this disease the secondary roots are abnormally abundant and often somewhat spongy in texture.

Particular attention is called to this disease because a good many nursery trees have been sold in the Northwest with the roots affected by it. A safer rule is to reject all trees diseased with the galls, even if the latter have been removed. We have found that they are sure to appear again.

No remedy is known, and, as the disease appears to be contagious, every effort should be made to prevent the sale of nursery stock affected by it.

Prof. J. W. Toumey has recently discovered in Arizona that the crown gall of the almond is caused by a slime mold which he names *Dendrophagus globosus*.

I have been unable to discover this or any similar organism in the galls on apple roots.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C. The missing numbers have been discontinued, being superseded by later bulletins.

16. Leguminous Plants. Pp. 24.
21. Barnyard Manure. Pp. 32.
22. The Feeding of Farm Animals. Pp. 32.
24. Hog Cholera and Swine Plague. Pp. 16.
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28. Weeds: And How to Kill Them. Pp. 32.
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30. Grape Diseases on the Pacific Coast. Pp. 15.
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32. Silos and Silage. Pp. 32.
33. Peach Growing for Market. Pp. 24.
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35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
37. Kafir Corn: Culture and Uses. Pp. 12.
38. Spraying for Fruit Diseases. Pp. 12.
39. Onion Culture. Pp. 31.
40. Farm Drainage. Pp. 24.
42. Facts About Milk. Pp. 29.
43. Sewage Disposal on the Farm. Pp. 20.
44. Commercial Fertilizers. Pp. 24.
45. Insects Injurious to Stored Grain. Pp. 24.
46. Irrigation in Humid Climates. Pp. 27.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
50. Sorghum as a Forage Crop. Pp. 20.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
53. How to Grow Mushrooms. Pp. 20.
54. Some Common Birds. Pp. 40.
55. The Dairy Herd. Pp. 24.
56. Experiment Station Work—I. Pp. 31.
57. Butter Making on the Farm. Pp. 16.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 32.
60. Methods of Curing Tobacco. Pp. 16.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 28.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 48.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 28.
67. Forestry for Farmers. Pp. 48.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
75. The Grain Smuts. Pp. 20.
76. Tomato Growing. Pp. 30.
77. The Liming of Soils. Pp. 19.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 28.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 24.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 30.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
89. Cowpeas. Pp. 16.
91. Potato Diseases and Treatment. Pp. 12.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 27.
94. The Vegetable Garden. Pp. 24.
95. Good Roads for Farmers. Pp. 47.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 28.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 32.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
109. Farmers' Reading Courses. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
111. Farmers' Interest in Good Seed. Pp. 24.
112. Bread and Bread Making. Pp. 39.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 27.
116. Irrigation in Fruit Growing. Pp. 48.
117. Sheep, Hogs, and Horses in the Northwest. Pp. 28.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 31.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 32.
122. Experiment Station Work—XVI. Pp. 32.
123. Red Clover Seed: Information for Purchasers. Pp. 11.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 26.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 42.
128. Eggs and their Uses as Food. Pp. 32.
129. Sweet Potatoes. Pp. 40.
130. The Mexican Cotton Boll Weevil. Pp. 30.
131. Household Test for Detection of Oleomargarine and Renovated Butter. Pp. 11.
132. Insect Enemies of Growing Wheat. Pp. 40.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 38.
135. Sorghum Sirup Manufacture. Pp. 40.
136. Earth Roads. Pp. 24.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
141. Poultry Raising on the Farm. Pp. 16.
142. The Nutritive and Economic Value of Food. Pp. 48.
143. The Conformation of Beef and Dairy Cattle. Pp. 44.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
146. Insecticides and Fungicides. Pp. 16.
147. Winter Forage Crops for the South. Pp. 36.
148. Celery Culture. Pp. 32.
149. Experiment Station Work—XX. Pp. 32.
150. Clearing New Land. Pp. 24.
151. Dairying in the South. Pp. 48.
152. Scabies in Cattle. Pp. 24.
153. Orchard Enemies in the Pacific Northwest. Pp. 39.
154. The Home Fruit Garden: Preparation and Care. Pp. 20.
155. How Insects Affect Health in Rural Districts. Pp. 20.

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